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ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Mountain Pine Beetle Infestation Characteristics in Ponderosa Pine, Kaibab Plateau, Arizona, 1975-1977

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A moderate mountain pine beetle infestation was characterized in standing and downed trees by low attack density, normal egg gallery length, and normal egg numbers. Larger trees produced more brood per unit surface area than smaller trees, and were infested to a greater height. Felled trees were attacked as heavily as standing trees. Trap trees might be used here to augment other beetle management approaches.

Keywords: Insect control, Scolytidae, *Dendroctonus ponderosae, Pinus ponderosa*

From 1973 to 1977, the mountain pine beetle (MPB) caused heavier than usual mortality in the old-growth ponderosa pine forest on the Kaibab Plateau in northern Arizona. Tree killing was most severe on the Kaibab National Forest, but the outbreak also affected stands in the adjacent Grand Canyon National Park.[3]

MPB activity is not new to the area. Blackman (1931) reported evidence of the following outbreaks: 1837-1846, 1853-1864, 1878-1882, 1886-1892, 1906-1910, and 1916-1926; the two most severe and widespread outbreaks were from 1886 to 1892 and 1916 to 1926. Localized tree mortality occurred from 1935 to 1938 and again in 1950.[4]

In 1973, groups of dead ponderosa pine were detected near East Lake. Surveys over a 4,000-acre area showed that trees were killed at a low but increasing level during 1971 and 1972. The infestation increased from about 2 trees per acre in 1973 to about 4.5 trees per acre in 1974, and assuming no control action, further increases were

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[3]*Parker, Douglas L. Biological evaluation, mountain pine beetle in ponderosa pine, North Kaibab Ranger District, Kaibab National Forest, Arizona, 1975. USDA For. Serv., Southwest. Reg., Albuquerque, N. Mex., Unpubl. Rep. R-3, 76-4, 7 p.*

[4]*Parker, Douglas L., and Robert E. Acciavatti. Biological evaluation and damage survey, mountain pine beetle in ponderosa pine, Kaibab Plateau, Kaibab National Forest, Arizona, 1975. USDA For. Serv., Southwest. Reg., Albuquerque, N. Mex., Unpubl. Rep. R-3, 75-24, 11 p.*

predicted for 1975. Infested trees were logged in the East Lake Timber Sale area in 1975 in an effort to suppress the outbreak, and a similar logging program was carried out again in 1976. Generally the logging was considered effective in reducing the density of beetle-attacked trees in the treatment area, but widely scattered trees were killed over about 75,000 acres.[3] The infestation declined throughout the entire area in 1977 and 1978.

Blackman (1931) studied the mountain pine beetle intensively on the Kaibab Plateau during the summers of 1925 and 1926. Essentially no research had been done on MPB in Arizona since, and the 1973 outbreak provided an opportunity to compare infestation characteristics with those reported by Blackman, and also to investigate the practice of using trap trees as a control technique, an approach he discussed briefly.

We observed MPB on the Kaibab Plateau in 1975, 1976, and 1977, in both standing and felled trees. Observations in standing trees included the relationship of attacks and brood production with respect to (a) tree height, (b) aspect (north or south), and (c) tree diameter. We also looked at Knight's (1960) method for predicting MPB trends, developed in Colorado and the Black Hills, for applicability to the Kaibab situation. Finally, we investigated the relationship between tree diameter and height of infestation.

Methods

Sample trees were selected at various locations in the Kaibab National Forest near Jacob Lake, Coconino County, Arizona, T36 and T37N. Trees were sampled during the period June 8-12, 1975; June 22-24, 1976; and on September 27 and 28, 1977.

Standing trees.—In 1975 and 1976 we sampled 30 standing trees infested the previous seasons. Standing trees were not sampled in 1977. Trees were felled, limbed, and bucked into sections as necessary to permit rolling. Bark samples, 6 by 6 inches square, were taken from the north (N) and south (S) sides at 5 feet above the ground line and thereafter at 10-foot intervals as high as evidence of MPB infestation could be found. From each sample we recorded (a) number of attacks as indicated by beginnings of egg galleries, (b) total length of egg galleries, and (c) number of living insects (generally larvae).

Felled (trap) trees.—Trap trees were sampled the same as standing trees; however fewer trees were sampled, and diameter classes were not established. Instead of N-S, top and bottom of the log were the two aspect variables chosen for sampling. Trap trees sampled in 1975 were pushed over by bulldozers during road building operations about 1-2 months prior to beetle flight. Some pushed-over trees still had root contacts, but most had none. Trap trees were felled in early July of 1976 and 1977, prior to the onset of the MPB attack period. All trap trees sampled were in the East Lake Timber Sale area, on Tater Ridge and Dog Point.

Where appropriate, data were subjected to analysis of variance for an unbalanced design. Differences were significant at the 0.05 level.

Results and Discussion

Standing Trees

Attack density.—The attack density patterns observed, from 0.77 to 4 attacks per square foot (table 1), are light for MPB in ponderosa pine. Blackman (1931), working in the same area, reported from 4 to 9 per square foot, with an

Table 1.—Mean attack and brood density, and egg gallery length, mountain pine beetle in standing ponderosa pine, Kaibab Plateau, Arizona, 1975-1976

	Number of trees		Number of samples		Attack density		Length egg gallery		Brood density	
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
					no./ft²		*in/ft²*		*no./ft²*	
Diameter class										
1 (11-15")	9	4	70	30	1.5	1.7	84.6	90.6	16.0	22.8
2 (16-20")	9	12	86	90	1.5	2.8	93.7	91.2	24.0	34.5
3 (20"+)	10	7	108	76	2.4	4.0	101.1	118.1	32.4	73.8
Side of tree										
North	28	23	132	98	1.7	3.5	95.9	100.0	29.7	50.7
South	28	23	132	98	1.4	3.0	92.1	100.8	20.1	53.6
Sample height										
5'	28	23	56	46	1.5	3.3	91.9	107.4	29.4	68.3
15'	28	23	56	46	2.6	3.4	100.1	110.4	26.2	46.5
25'	27	21	54	42	3.2	3.6	98.7	113.6	16.5	40.3
35'	25	15	50	30	1.4	2.9	81.2	83.3	23.6	52.6
45'	13	10	26	20	.8	3.0	103.2	86.6	26.9	39.7
55'	6	4	12	8	2.0	2.5	90.5	80.9	48.0	8.5
65'	4	1	8	2	1.3	4.0	87.5	72.8	58.0	81.0
75'	1	0	2	0	—	—	136.5	—	34.0	—

Table 2.—Infestation heights (in feet) and stem diameters (in inches), mountain pine beetle in standing ponderosa pines, Kaibab Plateau, Arizona, 1975-1976

Year	Number of trees	Tree diameter at breast height		Height at upper limit of infestation		Tree diameter at upper limit of infestation	
		Mean	Range	Mean	Range	Mean	Range
1975	28	19.5	12.4 - 42.5	42.5	15-75	11.3	6.8 - 19.4
1976	23	18.7	11.0 - 38.1	35.0	15-65	12.0	7.5 - 16.4

average of about 5.75. Schmid (1972) reported means more or less similar to those of Blackman in the Black Hills in 1965 and 1966. W. F. McCambridge[5] indicated that the MPB attack density pattern in the current Colorado Front Range infestation (also in ponderosa pine) ran consistently around eight attacks per square foot.

The attack density observed both years was so variable—in most cases the coefficient of variation was over 100% due to many zero counts—that standard statistical procedures were not generally useful. However the 1976 data, after eliminating the poorly represented 55- and 65-foot heights, showed that mean attack density varied significantly only by diameter class, i.e., number of attacks increased linearly with increase in diameter size. No variation was indicated with side of tree (N or S) or height of sample. No interactions between diameter class, aspect, or sample height were evident. Inspection of the 1975 data indicates a similar general pattern; however, the attack density-diameter class relationship is inconsistent.

Egg gallery length.—Even though the attack density was low, the inches of egg gallery per square foot, which provides an indication of egg production, appears relatively high (table 1). There was an average of about 93 inches of egg gallery per square foot in trees sampled in 1975, and 100 inches in 1976. These measurements are comparable to average lengths recorded by Schmid (1972) and McCambridge[5] where attack densities were higher; Blackman (1931) did not discuss egg gallery lengths. It appears that the low attack density was offset by increased egg gallery construction and egg laying.

Brood density.—Data for brood density (table 1) were similarly characterized by high variability. Average brood density was considerably higher than that reported by Blackman (1931), who cited averages of 5.3 and 2.32 beetles per square foot in 1925 and 1926, respectively. However, Blackman referred to "beetles," and our insects were, in many cases, still in the larval stage. Additional mortality could have been expected before most of the insects reached the adult stage. Therefore our results are probably not comparable to Blackman's. Also Blackman's studies were conducted during the population collapse phase of an outbreak; the current study was conducted during what we considered early stages of an outbreak.

Analysis of the 1976 data revealed significant differences in brood numbers versus diameter class, i.e., the large trees showed greater brood density both years. Aspect and sample height were not significant. Aspect did show a difference in 1975, and density was greater on the north sides of the trees.

Height of infestation and associated stem diameters.—As expected, larger trees were infested to a greater height (fig. 1). Mean height of infestation was 42.5 feet in 1975 and 35.0 feet in 1976 (table 2). These figures are similar to those of Blackman (1931), who reported an average height of infestation (137 trees) of 39.5 feet. Mean tree diameter at the upper limit of infestation in our study was about the same both years, 11.3 and 12.0 inches.

Infestation trend.—Efforts to test the applicability of Knight's (1960) sequential sampling scheme to the Kaibab situation yielded results as follows: the 1975 data (samples from 5 feet only; 56 samples, 379 insects) fall in the "no decision" zone between a static and an increasing trend (90% confidence interval). In practice when this occurs, the trend is considered to be increasing. The 1976 data (46 samples, 775 insects) indicate an increasing trend. Aerial detection survey records show that tree mortality remained about static from 1975 to 1976, while tree losses decreased from 1976 to 1977. Logging of infested trees can be presumed to have altered the situation and may be, at least in part, responsible for the loss trend not following what would have been predicted. The sequential sampling

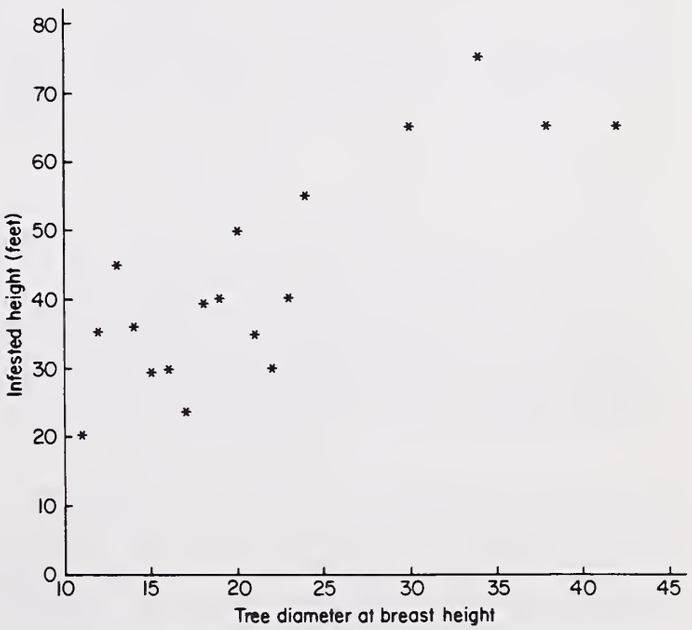

Figure 1.—Mean infestation heights and tree diameters, Kaibab Plateau, Arizona, 1975-1976. (N=51)

[5]*Personal communication, W. F. McCambridge, Entomologist, Rocky Mt. For. and Range Exp. Stn., Fort Collins, 1977.*

Table 3.—Mean attack and brood density and egg gallery length, mountain pine beetle in ponderosa pine, trap trees, Kaibab Plateau, Arizona, 1975-1977

	Number of trees			Number of samples			Attack Density			Length of egg gallery			Brood density		
	1975	1976	1977	1975	1976	1977	1975	1976	1977	1975	1976	1977	1975	1976	[1]1977
							no./ft²			*in/ft²*			*no./ft²*		
Side of tree															
Top	16	13	22	98	61	163	0.9	3.1	0.4	44.5	55.5	7.8	16.7	5.2	—
Bottom	16	13	22	98	61	163	2.5	3.5	3.0	66.9	67.5	51.9	36.4	7.5	—
Sample height[2]															
5′	16	13	22	32	26	44	2.6	4.8	2.0	77.9	91.5	33.6	24.6	15.9	—
15′	15	13	22	30	26	44	1.9	3.4	1.8	59.6	86.9	28.8	25.5	2.9	—
25′	15	12	20	30	24	40	0.9	4.0	1.6	59.7	72.3	29.4	25.2	4.2	—
35′	15	11	13	30	22	26	1.3	2.2	1.7	61.4	49.4	28.8	30.7	5.1	—
45′	14	8	7	28	16	14	1.0	1.8	1.1	49.9	40.2	29.4	23.8	3.7	—
55′	10	2	4	20	4	8	1.4	5.0	1.5	43.4	57.0	25.0	38.5	0	—
65′	7	2	1	14	4	2	.9	0	2.0	27.1	45.0	14.0	22.0	0	—
75′	3	0	0	6	0	0	0	—	—	30.7	—	—	11.3	—	—
85′	1	0	0	2	0	0	0	—	—	24.0	—	—	4.0	—	—

[1]*Brood density not recorded in 1977.*
[2]*Distance toward top of tree from original ground line; top and bottom samples combined for each height.*

scheme was inadequately tested to tell with confidence if it is or is not of value for predicting MPB infestation trends in Kaibab Plateau ponderosa pine.

Trap Trees

Attack density.—Mean attack densities were low, ranging from 1-2, 1-5, and 1-2 per square foot in 1975, 1976, and 1977, respectively (table 3). Each year's data showed great variability, largely resulting from many samples having no attacks. Attack densities in trap trees were generally comparable to densities in standing trees. Analysis of the slightly less variable 1976 data, again eliminating the poorly represented heights above 45 feet, showed a generally decreasing attack density with height. No differences were indicated between top and bottom of logs in 1976; however, major differences were recorded in 1975 and 1977. Attack density in 1976 was about double that in 1975 in the lower part of the sample logs; this was accompanied by much less variability.

Brood density.—Brood density patterns in the trap trees were similar to those in the standing trees in 1975 (table 3) but dropped markedly in 1976. The reasons for this are not known conclusively but the increased attack density may have been a factor. Analysis of the brood data (both years) showed significantly more brood was produced on the undersides of the logs. No differences were associated with position along the length of the tree.

Overall, the data support Blackman's (1931) contention that trap trees may provide a useful means for reducing low level MPB populations in the Kaibab area. Trap trees were attacked and did take a portion of the flying beetles out of the population. Recently felled trap trees appear to be highly attractive to the beetle. In one instance, five trap trees were cut at a location more than 1/4 mile from the nearest known infested trees and all five were attacked. Adjacent standing trees were never attacked. Land managers might consider this approach, alone or combined with logging of infested trees and other appropriate measures, when the next MPB outbreak occurs in the Kaibab area.

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